UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/883,922	06/20/2001	Toshiaki Ono	010789	3735

23850 7590 09/11/2003

ARMSTRONG,WESTERMAN & HATTORI, LLP
1725 K STREET, NW
SUITE 1000
WASHINGTON, DC 20006

EXAMINER	
ANDERSON, MATTHEW A	
ART UNIT	**PAPER NUMBER**
1765	

DATE MAILED: 09/11/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

PTO-90C (Rev. 07-01)

Office Action Summary	Application No.	Applicant(s)
	09/883,922	ONO ET AL.
	Examiner	Art Unit
	Matthew A. Anderson	1765

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *20 June 2003*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1,2,4,5 and 8-16* is/are pending in the application.

4a) Of the above claim(s) ____ is/are withdrawn from consideration.

5)☐ Claim(s) ____ is/are allowed.

6)☒ Claim(s) *1,2,4,5 and 8-16* is/are rejected.

7)☐ Claim(s) ____ is/are objected to.

8)☐ Claim(s) ____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *20 June 2001* is/are: a)☐ accepted or b)☒ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on ____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☒ All b)☐ Some * c)☐ None of:

1.☒ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. ____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) ____ .
4) ☐ Interview Summary (PTO-413) Paper No(s). ____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

DETAILED ACTION

Claim Rejections - 35 USC § 103

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

2. Claims 8-16 are rejected under 35 U.S.C. 103(a) as being unpatentable over Iida et al (EP0962557) in view of Wolf et al. (Silicon Processing for the VLSI Era, Volume 1: Process Technology, Lattice Press, Sunset Beach, CA, USA, pp. 8-11, 27-33, 36-72, 124, 139-142, 1986.).

Iida et al. discloses a method of pulling a silicon single crystal ingot according to the Cz (Czochralski) method. The cooling rate of the ingot from 1150-1080'C was disclosed as 2.30'C/min or more. The rapid cooling was said to decrease the density and size of the grown in defects. Nitrogen doping was also suggested in the range from 1.0×10^{10} to 5×10^{15} atoms/cm 3 (page 2 item 12). Paragraph 10 page 2 indicates that a faster crystal growth speed (i.e. a faster cooling rate) improves productivity. Iida discloses an oxygen concentration of 1.0×10^{18} atoms /cm^3 or less in item 13 on page 2. This value prevents surface defects although it is silent concerning bulk wafer defects.

Iida et al. does not specify the cooling rate in the 1000-850'C temperature range.

Wolf et al. on page 11 discloses that interstitial agglomeration defects are prevented by quenching during the temperature range interstitial point defects are mobile within the crystal lattice (i.e. from 1421'C to about 950'C). The agglomerated interstitial point intrinsic defects are dislocation loops. On page 49, it is further intimated that the temperature range of the diffusion (i.e. mobility) of supersaturated Si self-interstitial point defects is between about 400 to 1200 degrees Celsius. On pages 59-61 oxygen in Si is detailed as forming precipitates at approximately 550-800'C. On page 66, oxygen precipitates are disclosed as good for intrinsic gettering sites. Fig. 16 discloses the relationship of oxide in Si to wafer warpage resistance. Nitrogen doping for the same purpose is suggested on page 32. Page 140 discloses the warpage resistance as critical for epitaxial Si wafers. On page 141 the use of IG (intrinsic gettering) of the substrates prior to deposition is described. The examiner notes that the processing parameters are result effective as disclosed on page 61.

It would have been obvious to one of ordinary skill in the art at the time of the present invention to combine Iida et al. with Wolf et al. because Iida et al. discloses the quenching of Si ingots pulled with the Cz method to prevent the agglomeration of vacancy point defects in a certain temperature range and Wolf et al. discloses that the quenching in the temperature range of 1421 to 400 'C prevents agglomeration of interstitial and vacancy point defects in Cz Si. The use of quench cooling in Cz Si pulling is thus well established.

In respect to claims 8,9, 10, 13,14, 15 it would have been to one of ordinary skill in the art at the time of the present invention to optimize the cooling rate because Iida et

al. suggests faster rates increase the productivity of the process and such optimization would have been achieved with only routine experimentation.

Further, it would have been obvious to one of ordinary skill in the art at the time of the present invention to optimize the temperature range of fast cooling because Iida et al. discloses such ranges as useful for Si defect control and Wolf et al. suggests defect agglomeration as reduced with quenching (i.e. high cooling rates).

In respect to claims 8, 9, 10, 11, 13, 14, 15, 16, it would have been obvious to one of ordinary skill in the art at the time of the present invention to optimize the oxygen and nitrogen concentration of the Si single crystal because Wolf et al suggests an oxygen concentration of 25 ppma (page 27; this is 1.25 x10^{18} atoms/cm^3 by extrapolation of the typical concentrations given on page 59) and suggests nitrogen doping for warpage resistance. Oxygen content was known to allow oxygen precipitates and thus IG to form in the silicon wafer.

In respect to claims 13, 14, 15, it would have been obvious to one of ordinary skill in the art at the time of the present invention to grow an epitaxial layer on a silicon wafer produced from an Si ingot because such epitaxial layers (including those formed on IG substrate wafers) were known in the art. (see Wolf page 124).

In respect to claims 8, 9, 10, 13, 14, 15 it would have been obvious to one of ordinary skill in the art at the time of the present invention to optimize the fast cooling and slow cooling of a silicon crystal through the specified temperature ranges because this was disclosed as useful for forming oxygen precipitates and thus IG substrates for further production of Silicon epitaxial wafers and because such optimization of result

effective process parameters would have been achieved with only routine experimentation.

3. Claims 1,2,4,5 are rejected under 35 U.S.C. 103(a) as being unpatentable over Iida et al (EP0909840) in view of Wolf et al. (Silicon Processing for the VLSI Era, Volume 1: Process Technology, Lattice Press, Sunset Beach, CA, USA, pp. 8-11, 27-33, 36-72, 124, 139-142, 1986.).

Iida et al. discloses a method of pulling a silicon single crystal ingot according to the Cz (Czochralski) method. The cooling rate of the ingot from 1150-1080'C was disclosed as 20 minutes or less (i.e. a cooling rate of 3.5'C/minute or more). The cooling from 1250-1200"c was also given as at this rate in an alternative embodiment. The rapid cooling was said to decrease the density and size of the grown in defects. The rapid cooling was described to give an excellent chip yield (abstract). No disclosure of nitrogen doping is given in Iida et al.

Iida et al. does not Iida et al. does not specify the cooling rate in the 1200-1050'C temperature range be 7.3'C/min or more.

Wolf et al. on page 11 discloses that interstitial agglomeration defects are prevented by quenching during the temperature range interstitial point defects are mobile within the crystal lattice (i.e. from 1421'C to about 950'C). The agglomerated interstitial point intrinsic defects are dislocation loops. On page 49, it is further intimated that the temperature range of the diffusion (i.e. mobility) of supersaturated Si self-interstitial point defects is between about 400 to 1200 degrees Celsius. On pages 59-61 oxygen in Si is detailed as forming precipitates at approximately 550-800'C. On

page 66, oxygen precipitates are disclosed as good for intrinsic gettering sites. Fig. 16 discloses the relationship of oxide in Si to wafer warpage resistance. Wolf et al suggests an oxygen concentration of 25 ppma (page 27; this is 1.25 $x10^{18}$ atoms/cm^3 by extrapolation of the typical concentrations given on page 59) as typical for Cz pulled Si single crystal. Page 140 discloses the warpage resistance as critical for epitaxial Si wafers. On page 141 the use of IG (intrinsic gettering) of the substrates prior to deposition is described. The examiner notes that the processing parameters are result effective as disclosed on page 61.

It would have been obvious to one of ordinary skill in the art at the time of the present invention to combine Iida et al. with Wolf et al. because Iida et al. discloses the quenching of Si ingots pulled with the Cz method to prevent the agglomeration of defects in a certain temperature range and Wolf et al. discloses that the quenching in the temperature range of 1421 to 400 'C prevents agglomeration of interstitial and vacancy point defects in Cz Si. The use of quench cooling in Cz Si pulling is thus well established.

In respect to claims 1, 2 , 4,5, it would have been to one of ordinary skill in the art at the time of the present invention to optimize the cooling rate because Iida et al. suggests faster rates increase the productivity of the process and such optimization would have been achieved with only routine experimentation.

Further, It would have been obvious to one of ordinary skill in the art at the time of the present invention to optimize the temperature range of fast cooling because Iida

et al. discloses such ranges as useful for Si defect control and Wolf et al. suggests defect agglomeration as reduced with quenching (i.e. high cooling rates).

In respect to claims 1, 2, 4, 5, it would have been obvious to one of ordinary skill in the art at the time of the present invention to optimize the oxygen concentration of the Si single crystal because and Wolf et al suggests an oxygen concentration of 25 ppma (page 27; this is 1.25 $x10^{18}$ atoms/cm^3 by extrapolation of the typical concentrations given on page 59) and suggests oxygen as important to reducing defects in epitaxial wafers by the formation of IG oxygen precipitates (page 141-142).

In respect to claim 4,5, it would have been obvious to one of ordinary skill in the art at the time of the present invention to grow an epitaxial layer on a silicon wafer produced from an Si ingot because such epitaxial layers (including those formed on IG substrate wafers) were known in the art. (see Wolf page 124).

In respect to claims 1,2,4,5 , it would have been obvious to one of ordinary skill in the art at the time of the present invention to optimize the fast cooling and slow cooling of a silicon crystal through the specified temperature ranges because this was disclosed as useful for forming oxygen precipitates and thus IG substrates for further production of Silicon epitaxial wafers and because such optimization of result effective process parameters would have been achieved with only routine experimentation.

Response to Arguments

4. Applicant's arguments filed 6/20/2003 have been fully considered but they are not persuasive.

The argument that the combination does not suggest the epitaxial IG wafers produced by the present method is not convincing. The examiner points to the known use of temperature and cooling control to effect both the limitation of defect formation and the promotion of beneficial defect formation (i.e. the oxygen precipitates vital to Intrinsic Gettering). Wolf et al. describes IG as beneficial, thus at least suggests a sufficient amount of oxygen precipitates was previously obtained.

The teaching away argument is not convincing. Iida (EP 0990840) discloses few crystal defects without specifying the oxygen concentration required. Iida (EP 0962557) merely states a preference for 'low' oxygen to add to the defect avoidance. This is not rule out higher concentrations. Page 67 of Wolf et al. suggests optimization of oxygen concentrations for Si wafers.

The argument that neither Iida or Wolf suggests a method of increasing the density of oxygen precipitates is not convincing. Wolf et al. discloses oxygen precipitate creation on page 61. This suggests an increase in density. Page 67 discloses a method of nucleation and growth of oxygen precipitates.

The argument against the formation of precipitates in the range from 550-800'C is not convincing. Page 67 Fig. 24 shows nucleation (i.e. formation) of oxygen precipitates from donors at 600'C.

The arguments directed to claims 1,2,4, 5 are moot in light of the new grounds of rejection necessitated by amendment.

The argument that the specific cooling rates and ranges are not in the references is not persuasive. The references in combination suggest the result effective parameter optimization of the cooling rate and temperature ranges.

Claim Rejections - 35 USC § 112

5. Claim 15 is rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

The phrase "...with 5 x1013 atoms/cm3 to 1x1016 atoms/cm3..." is not particular as to what the dopant is or is not.

From other claims in the application, the examiner has deduced this is to refer to nitrogen doping and has examined the claim above under this assumption.

Conclusion

6. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within

TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Matthew A. Anderson whose telephone number is (703) 308-0086. The examiner can normally be reached on M-Th, 6:30-5.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nadine Norton can be reached on (703) 305-2667. The fax phone numbers for the organization where this application or proceeding is assigned are (703) 872-9306 for regular communications and (703) 872-9306 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is (703) 308-0661.

NADINE G. NORTON
PRIMARY EXAMINER

MAA
September 10, 2003